POST-OPERATIVE NON-SEPTIC LEUCOCYTOSIS AND OTHER BLOOD CONDITIONS.[1]

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The following observations were undertaken, in the first instance, for the purpose of establishing a normal standard of leucocytosis in non-septic post-operative wound repair. It was thought that could such a standard be established, any material departure from it, following an operation, might be regarded as an early sign of post-operative sepsis, and possess a clinical value accordingly.

The first series of observations in ten cases was begun in the autumn of 1898, and completed prior to the annual meeting of the Michigan State Medical Society in May, 1899, at which meeting, by request, I presented a preliminary report, which was published in the *Transactions* for that year. In this first series the chief interest attaches to the rise and fall of the post-operative leucocytosis, a differential count of varieties of leucocytes not being attempted. It was observed, however, that the numerical value of the red blood corpuscles as well as the hæmoglobin *rose after operation*, even where considerable blood had been lost at the time of operation, and this led, in the second series, to a more systematic study of the red elements and hæmoglobin, for the purpose of ascertaining whether this increase in peripheral blood value following operation was real or apparent. At the same time the leucocytes were studied not only as a whole, but in the relation of their varieties to each other. If by blood examination it were possible to differentiate between an aseptic wound repair and the commencement of a septic process following operation at a time sufficiently early to be of practical value to the surgeon, a study of the blood in all surgical cases of major importance would be the rule of practice; and while the conclusions to be gathered from the records of my two series of cases are perhaps not sufficient for the establishment of fixed standards, the findings in certain respects appear so constant as to warrant their acceptance as *rules* in the pathology of post-operative wound-repair.

I am by no means so certain of the *clinical* importance of blood examinations in these cases. It was thought that such examinations systematically made would show a marked "jump" from the leucocytosis (if it existed at all) of the aseptic process to the familiar blood picture of sepsis, and that at a time so early as to be of practical value. My observations seem to have demonstrated two points of some importance in this regard:

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[1] Read before the Chicago Pathological Society, May 12, 1902.

First, that the leucocytosis of a normal wound-repair (even where healing is rapid and by first intention, when no drainage is employed, as in simple laparotomy for tuberculous peritonitis) may be very marked; and second, that the "jump" in degree of leucocytosis between the two conditions does not exist at all.

On the other hand, these experiments demonstrate that at a time subsequent to operation, when the results of infection are most prone to appear, the leucocytosis of normal wound-repair is on the decline; and that if, therefore, the leucocytes appear in increasing number at such a time it may safely be assumed that infection has occurred, such other morbid conditions as effect similar changes in the constituent elements of the blood being eliminated. Further, that while in the blood of the healthy individual there is a standard average number of leucocytes (7500 to 1 c.mm., the different varieties occurring in practically uniform proportion), it is found that the subject for the operating-table, while not necessarily septic, is, of course, not in a normal condition of health, and will therefore present, very frequently, marked variations from this average, associated or not with anæmia or chlorosis. A count made prior to operation will, therefore, represent the "special normal" for each particular case to be observed, which it is of the first importance to ascertain if any significance is to be attached to the post-operative observations. The relative proportion between the various forms of leucocytes is also found to be very inconstant in such conditions as usually demand surgical relief, but this fact is of less importance to the present purpose.

In its relation to septic infection, then, a single examination of the blood made subsequent to operation is of little value either to pathology or diagnosis, since it may present a leucocytosis perfectly normal to one patient which would be quite as abnormal to another. A series of observations commencing six hours or more prior to operation and carried through the period when sepsis may be a possible element of danger will, on the other hand, convey much that is significant to the progress of the wound-repair.

The method of observation adopted in my first series of ten cases was as follows:

First. A complete quantitative examination of the blood (exclusive of a differential leucocyte count) was made from six to twenty hours prior to operation. (In Case VI., first series, this examination was made three days prior to operation, the delay being occasioned by the appearance of menstruation, and a second leucocyte count was made seventeen hours before operation.)

Second. A leucocyte count was made six hours after completion of operation.

Third. A second quantitative examination similar to the first was made twenty-four to thirty hours after operation except in the first two cases.

Fourth. A leucocyte count was made every twenty-four hours thereafter until all danger of sepsis had passed and the leucocytes had fallen to practically a normal number.

The same instruments were employed in all cases (the Thoma-Zeiss hæmocytometer and von Fleischl's hæmoglobinometer). My pipette for red corpuscles counts rather lower than it should; but as the same pipette was used constantly, and comparative observations are all that are necessary, the results meet the requirements.

In estimating "color index," 5,000,000 per cubic millimetre of red corpuscles was taken as the normal 100 per cent. This is rather higher than normal for women, but a single standard for all cases was considered advisable. Like conditions of nutrition were observed in all examinations, and by reason of the surgical nature of the cases, of course, digestion leucocytosis was always to be excluded from consideration.

The greatest possible care was exercised in procuring the specimens, diluting and mixing the same, and counting; but as absolute accuracy is not obtainable with the Thoma-Zeiss apparatus, note was not made of anything under 100,000 per cubic millimetre in counting the red cells, nor under 100 in the colorless elements.

The blood in all cases is peripheral and obtained from the finger-tip by a puncture sufficiently deep to allow of procuring the specimen without compression.

Such other precautions as were possible were taken to avoid errors in technique.

For obvious reasons, major operations alone were selected for the purpose, both in the first and second series. In the first series of ten cases all were abdominal sections except one, which was an amputation of the breast for malignant disease. One of the abdominal operations was also for malignant disease. None of the second series was a malignant case. Neither of the malignant cases presented evidence of cachexia, which, had it been present, would, of course, have rendered them valueless for the present purposes on account of the leucocytosis which characterizes the blood in such cases.

Notwithstanding the nature of the disease in a few instances in both series, so far as could be determined the general health in all cases was fairly good, with one exception (Case VII., Series II.).

There had been no history of recent suppuration, nor was any pus present in any of them at the time of operation nor subsequently during the periods of my observations.

Of the first series, nine were operations upon adult women, and one (the appendectomy) upon a vigorous young man.

Of the second series of seven cases all were abdominal sections in adult women.

The several operations in the two series were as follows:

SERIES I. Case I., abdominal section for oöphorectomy.

Case II., abdominal section for oöphorectomy (malignant).

Case III., abdominal section for ventrofixation.

Case IV., abdominal section for ventrofixation.

Case V., abdominal section for oöphorectomy.

Case VI., abdominal section for oöphorectomy.

Case VII., abdominal section for appendectomy.

Case VIII., amputation of the breast and removal of the axillary glands (malignant).

Case IX., abdominal section for removal of papillomatous cyst.

Case X., abdominal section for ovarian cyst.

SERIES II. Case I., abdominal section for removal of the tubes and ovaries.

Case II., abdominal section for ventrofixation and breaking adhesions.

Case III., abdominal section for removal of the tubes and ovaries.

Case IV., abdominal section for oöphorectomy.

Case V., abdominal section for gallstones.

Case VI., abdominal section for ventral hernia.

Case VII., abdominal section for abdominal tuberculosis.

The method adopted in the second series of observations, as above stated, is somewhat more exhaustive than that in the first, and consists in the following routine:

First. A quantitative examination, including a differential computation of leucocytes and the estimation of the proportion of nucleated erythrocytes, is made a few hours prior to operation. This, of course, necessitates the hardening and staining of cover-glass preparations.

(This additional and rather monotonous labor was suggested by the red-cell finding in the first series, where the second general examination, made from twenty-four to thirty hours after operation, invariably showed increase, at times startling, in the number of erythrocytes per cubic millimetre, and usually also in the hæmoglobin. It was thought that if this increase were real—*i. e.*, due to stimulation of the hæmogenetic function—there would appear with the increase in erythrocytes a proportional increase in nucleated red cells.)

Second. A leucocyte count is made six to twelve hours after operation.

Third. A second general examination similar to the first is made from twenty-four to thirty hours after operation.

Fourth. A leucocyte count is made every twenty-four hours following, as in the first series.

Fifth. A final general examination similar to the first is again made one hundred and twenty hours or more after operation, chiefly for the purpose of determining whether the apparent increase in erythrocytes is sustained.

To better illustrate the changes occurring in the blood in the course of these examinations four charts have been prepared.

Chart I. presents a table of the rise and fall of the leucocytosis, pulse and temperature (recorded at the time of the leucocyte count in each instance), time of examination relative to operation, and the character of the operation made in each case of the two series.

In studying this chart the following points are noted:

1. Case VII., Series I. (appendectomy; active inflammation not present). On the second day after operation two counts were made, four hours apart, as, owing to chill and rise in temperature, with the appearance of icterus, sepsis was feared, which the leucocyte count excluded.

2. Case V., Series II. (removal of gallstones). This case was recorded for fourteen days after operation, owing to continued leucocytosis, the explanation of which lay in an obstinate and persistent diarrhœa, with some bloody discharge from the bowels and considerable secondary anæmia, as shown by the final examination.

3. Same case as above. This count was made three days prior to operation, and, owing to my absence from town, observations on the second and third days after operation were not obtained.

4. Case VII., Series II. (laparotomy for abdominal tuberculosis). This case died from shock of multiple perforation of the gut sixty-six hours after operation and twelve hours after the last leucocyte count, which was made evidently about two hours *after* perforation occurred. Necropsy showed an extensive "dry gangrenous" condition of a large part of the intestinal wall.

This is the one exception to the generally fair health in all of the cases recorded.

From the foregoing chart a supplementary table of averages is compiled, representing graphically the mutual relation of pulse, temperature, and leucocyte variation. (Chart II.)

This relation, as may be seen by reference to Chart I., is not constant; indeed, except in a general way, the pulse, temperature, and leucocytosis appear to bear no direct relationship to each other in aseptic wound-repair.

A few salient points should be noted from these tables:

(*a*) Of the seventeen cases recorded, maximum leucocytosis was reached in from six to twelve hours after operation in nine, in from twenty-four to thirty hours after operation in six, and in from forty-eight to fifty-four hours after operation in one.

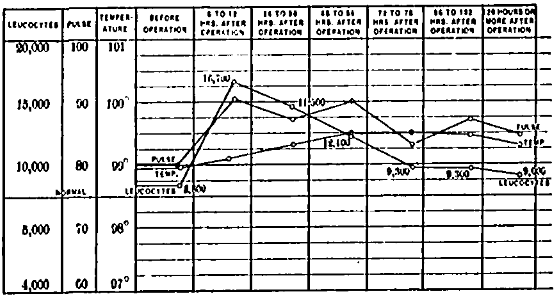
CHART I. (SERIES I. AND II.)—TABLE OF LEUCOCYTOSIS, PULSE, TEMPERATURE, ETC., IN SEVENTEEN CASES.

Case.	6 to 24 hours prior to operation.	6 to 12 hours after operation.	24 to 30 hours after operation.	48 to 54 hours after operation.	72 to 78 hours after operation.	96 to 102 hours after operation.	120 or more hours after operation.	Remarks.
I.	14,700 P. 90 T. 99	18,800 P. 88 T. 100.2	20,000 P. 84 T. 99.8	12,100 P. 80 T. 100.4	18,000 P. 96 T. 99.6	7,800 P. 94 T. 99.4	9,800 P. 88 T. 99.4	Oöphorectomy.
II.	12,500 P. 86 T. 99.4	21,000 P. 84 T. 99.2	13,400 P. 80 T. 100.2	9,400 P. 90 T. 100.4	7,600 P. 84 T. 100.2	7,200 P. 88 T. 100	....	Oöphorectomy (malignant).
III.	6,000 P. 88 T. 99	10,000 P. 84 T. 99.2	11,000 P. 78 T. 99	8,000 P. 68 T. 100.2	6,000 P. 64 T. 99.6	....	....	Ventrofixation.
IV.	6,000 P. 84 T. 98.5	15,000 P. 100 T. 98	15,600 P. 102 T. 99.4	18,000 P. 94 T. 99.2	10,000 P. 90 T. 99.2	10,000 P. 100 T. 99.6	5,900 P. 92 T. 100.2	Ventrofixation.
V.	9,000 P. 76 T. 98.5	17,000 P. 90 T. 99.4	11,000 P. 94 T. 99.2	11,000 P. 90 T. 98.5	9,400 P. 90 T. 98.5	8,100 P. 96 T. 99	....	Oöphorectomy.
VI.	12,200 P. 80 T. 99.8	13,800 P. 80 T. 99	6,600 P. 84 T. 99.4	13,100 P. 80 T. 99.8	11,800 P. 76 T. 99.8	9,000 P. 64 T. 99.4	....	Oöphorectomy.
VII.	10,000 P. 60 T. 98.4	18,100 P. 70 T. 98.8	11,200 P. 60 T. 99	7,000 7,200 P. 80 T. 100.4	12,000 P. 72 T. 99	10,600 P. 60 T. 99	6,800 P. 60 T. 98.8	Appendectomy.
VIII.	7,600 P. 70 T. 98	18,800 P. 112 T. 99	16,300 P. 102 T. 99.6	11,900 P. 90 T. 99.4	6,800 P. 90 T. 99.6	....	....	Amputation of breast (malignant).
IX.	8,800 P. 68 T. 99.6	7,800 P. 84 T. 99.2	10,900 P. 100 T. 99.2	7,500 P. 92 T. 100	7,500 P. 89 T. 98.6	2,800 P. 81 T. 99.4	....	Cystic tumor.
X.	5,800 P. 102 T. 100	10,900 P. 88 T. 98.4	11,200 P. 80 T. 99.4	....	6,600 P. 74 T. 99.8	....	....	Cystic tumor.
I.	5,900 P. 64 T. 99.4	12,800 P. 80 T. 98	20,900 P. 96 T. 99.8	15,600 P. 76 T. 98	10,600 P. 72 T. 99	7,500 P. 72 T. 100	5,900 P. 72 T. 99.6	Removal of tubes and ovaries.
II.	16,500 P. 94 T. 99.4	26,800 P. 100 T. 99.8	18,800 P. 86 T. 100	20,000 P. 90 T. 99.8	10,000 P. 90 T. 100.6	13,100 P. 110 T. 100.6	14,800 P. 90 T. 100	Ventrofixation and adhesions.
III.	6,900 P. 64 T. 97.8	7,200 P. 100 T. 100	4,400 P. 82 T. 98.8	6,000 P. 74 T. 98.5	5,000 P. 80 T. 99	6,900 P. 72 T. 98.6	....	Oöphorectomy.
IV.	7,500 P. ... T. ...	17,800 P. 82 T. ...	11,900 P. 72 T. 98.8	....	10,700 P. 80 T. 100.1	6,600 P. 76 T. 99.1	....	Oöphorectomy.
V.	5,000 P. 70 T. 98	11,000 P. 98 T. 98.8	12,600 P. 72 T. 98.8	....	....	18,500 P. 103 T. 98.6	16,000 P. 114 T. 99.4	Gallstones.
VI.	10,000 P. 68 T. 98.2	....	21,500 P. 80 T. 98.6	16,000 P. 98 T 99.6	13,100 P. 90 T. 99.6	12,600 P. 98 T. 99	10,000 P. 90 T. 98.6	Ventral hernia.
VII.	14,000 P. 122 T. 100.2	23,000 P. 114 T. 100.6	26,000 P. 106 T. 99.4	19,000 P. 160 T. sub.	....	....	....	Laparotomy for abdominal tuberculosis.

(*b*) Exclusive of Case VII., Series II.—which from its nature should obviously be omitted from present consideration—the five highest leucocyte counts recorded occurred as follows: Case II., Series II., 26,300, six hours after operation—ventrofixation; Case II., Series I., 24,000, six hours after operation—oöphorectomy; Case VI., Series II., 21,500, twenty-four hours after operation—ventral hernia; Case I., Series II., 20,900, twenty-four hours after operation—oöphorectomy, etc.; Case I., Series I., 20,000, twenty-four hours after operation—oöphorectomy. Excepting in these cases no leucocytosis of 20,000 to 1 cubic millimetre or more was observed.

(*c*) One other of these cases requires special mention—Case IX., Series I. It will be observed that the leucocyte count before operation in this case indicated a condition of leucopænia, being 3800 (considerable chlorosis also existed in this case, the color index being 0.50), and on the fourth day after operation it fell to 2800. The maximum leucocytosis in this case occurred about thirty hours after operation, and amounted to 10,900, which would be equivalent to 15,000 in one whose blood was normal to start with.

CHART II.



Average pulse, temperature, and leucocytosis in seventeen cases.

(*d*) The least variation in the leucocyte count occurred in Case III., Series II., which was an oöphorectomy. The nature of the operation in itself, therefore, seems to have little effect upon the degree of leucocytosis.

From Chart II.—which represents graphically the *average* pulse, temperature, and leucocytosis in the seventeen cases—it will be seen that the leucocytosis (taking the average) rises to its maximum in from six to twelve hours after operation, from which point it steadily declines to normal, which may be said to be reached about one hundred and twenty hours after operation. That there may be many exceptions to this average, however, without signifying sepsis is a fact demonstrated in the tables of Chart I.

CHART III. (SERIES II.)—PER CENT. AND ACTUAL NUMBER PER C.MM. OF RESPECTIVE VARIETIES OF LEUCOCYTES BEFORE AND AFTER OPERATION.

Case.	Time.	Small lympho-cytes.	Large lympho-cytes.	Poly-morpho-nuclear neutro-philes.	Eosino-philes.	Transi-tional forms.	Myelo-cytes.	Total.
I.	12 hours prior to operation	31 % 1829	12 % 708	54 % 3186	Small fract. %	3 % 177	....	5,900
I.	30 hours after operation	2 % 418	11 % 2299	84 % 17556	None	3 % 627	....	20,900
I.	126 hours after operation	9 % 531	12 % 708	75½ % 4454+	½ % 29+	3 % 177	....	5,900
II.	18 hours prior to operation	10½ % 1732+	5 % 825	82 % 13530	....	2½ % 412+	....	16,500
II.	24 hours after operation	9 % 1692	7½ % 1410	81 % 15228	....	2 % 376	....	18,800
II.	168 hours after operation	22 % 3366	11½ % 1759+	61½ % 9409+	3½ % 535+	1 % 153	½ % 76+	15,300
III.	18 hours prior to operation	35 % 2205	15 % 945	45 % 2835	1 % 63	4 % 252	....	6,300
III.	24 hours after operation	7 % 504	6 % 432	84 % 6048	....	3 % 216	....	7,200
III.	120 hours after operation	37 % 2553	6 % 414	53 % 3657	1 % 69	3 % 207	....	6,900
IV.	12 hours prior to operation	43 % 3225	5 % 375	49 % 3675	1 % 75	2 % 150	....	7,500
IV.	30 hours after operation	9 % 1071	4 % 476	83 % 9877	....	4 % 476	....	11,900
IV.	126 hours after operation	28 % 1848	7 % 462	60 % 3960	1 % 66	3 % 189	1 % 66	6,600
V.[1]	3 days prior to operation	25 % 1250	10 % 500	62 % 3100	....	3 % 150	....	5,000
V.	6 days after operation	8 % 1000	10 % 1250	78 % 9750	1 % 125	3 % 375	....	12,500
V.	14 days after operation	18½ % 2886	8 % 1248	68½ % 10686	2 % 312	2½ % 390	½ % 78	15,600
VI.	12 hours prior to operation	10 % 1000	16 % 1600	68 % 6800	3 % 300	3 % 300	....	10,000
VI.	30 hours after operation	7 % 1505	5 % 1075	86 % 18490	....	2 % 430	....	21,500
VI.	150 hours after operation	13 % 780	10 % 600	75 % 4500	1 % 60	1 % 60	....	6,000
VII.[2]	60 hours prior to operation	19 % 2660	11½ % 1610	68 % 9520	½ % 70	1 % 140	....	14,000
VII.	30 hours after operation	7½ % 1950	6½ % 1690	85 % 22100	....	1 % 260	....	26,000

Chart III. is a table of the differential computation of leucocytes, in percentages and actual number per cubic millimetre, made shortly before operation, again twenty-four to thirty hours after operation (except in one instance), and lastly, one hundred and twenty or more hours after operation (also excepting one instance) in the seven cases of the second series.

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[1] In this case an accident to the cover-glass preparations prevented a differential computation on the first day after operation. One was made, therefore, on the sixth day when leucocytosis had declined to about the same degree as that of the first day after operation. Leucocytosis persisted at the fourteenth day, owing to diarrhœa and secondary anæmia. This experiment is therefore vitiated.

[2] This is the case which died from shock sixty-six hours after operation, making the final examination impossible.

The chief object here is to demonstrate again what has so frequently been done before, namely, that the principal change in the colorless elements of the blood in leucocytosis occurs in the neutrophiles, which are increased out of all proportion to the other leucocytes; indeed, in the instance of the small lymphocytes in my seven cases the second examination made during the maximum leucocytosis showed actual diminution in number per cubic millimetre in every case but one (Case VI., Chart III.).

The large lymphocytes are found, at the same time, slightly increased in actual number per cubic millimetre except in two cases (Cases III. and VI., Chart III.).

Transitional forms, also, at the same time are increased to some extent except in one case (Case III., Chart III.).

In the case of the polymorphonuclear neutrophiles, however, there are no exceptions, and the increase in actual number is so considerable as to be readily apparent, while in relative number their percentage rises sharply in all but one case (Case II., Chart III.), where it remains nearly stationary, owing to the existence of a marked leucocytosis prior to operation, with comparatively little variation in this respect during the whole course of observations. (See Case II., Series II., Chart I.)

In the first series of examinations, as before stated, two counts of the red corpuscles were made in eight cases—the first count shortly prior to operation, and the second from twenty-four to thirty hours after operation. I expected to find a diminution in erythrocytes following operation, especially in cases where any considerable blood was lost. The contrary, however, obtained. My attention was about this time called to an excerpt from an article by Ermanno Pinzani,[1] who found the red cells and hæmoglobin increased following oöphorectomy, and evidently believed the increase to be real.

The results in the eight cases of my first series were as follows:

Case III.—The red corpuscles increase, in the second examination, more than 500,000 over the count in the first examination; hæmoglobin remaining the same, thus lowering the "color index."

Case IV.—The numerical increase in the second over the first examination is 1,400,000, while the hæmoglobin advances from 70 per cent. to 90 per cent.

Case V.—The cellular increase is 1,000,000; hæmoglobin, 5 per cent.

Case VI.—In this case the increase is insignificant.

Case VII.—The numerical increase is 2,100,000, and hæmoglobin, 5 per cent.

Case VIII.—The increase is again insignificant, being only 100,000, hæmoglobin remaining unchanged.

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[1] American Journal of Obstetrics, April, 1899.

Case IX.—The numerical advance is 300,000; hæmoglobin, 5 per cent.

Case X.—The cell increase is 500,000, while the hæmoglobin advances 15 per cent.

On account of these rather unexpected findings it was thought best to carry the observations a little further in the second series. A third examination was, therefore, made in the latter series, one hundred and twenty hours or more after operation, to determine whether this increase in erythrocytes was sustained. At the same time cover-glass preparations from each examination were stained and a systematic search made for nucleated red cells. It was believed that if the advance in red corpuscles were real, and not merely a phenomenon of transient character occurring in the peripheral blood, there would be a noticeable increase of nucleated red cells in the circulating blood, such as obtains in any blood regenerative process, notably in the secondary anæmia following severe hemorrhage.

The results of these observations in the second series are shown in the tables of Chart IV. It will be seen that while in every instance the second examination shows an increase in erythrocytes over the first of from 100,000 to 1,000,000, the third examination shows a return of the red cells to practically the number counted at the first examination. The same is true of the hæmoglobin to all practical purposes.

The rule adopted in regard to the nucleated red cells was to record all observed while counting 300 leucocytes, taking a different cover-glass preparation for each 100 or 150 leucocytes counted, to avoid errors arising from faulty distribution of blood.

Only one case (Case I., Chart IV.) shows any practical increase in the number of nucleated erythrocytes. It is significant that this is the case which shows the greatest and most persistent increase in red cells of any of the series.

In view of the findings in this series it must, I think, be admitted that the apparent increase in the red cells following operation is not real—*i. e.*, due to the excitation of the hæmogenetic function, but rather is due either to the temporary abstraction of the fluid constituents from the blood or merely a phenomenon of the peripheral blood and of transient character.

To a certain extent the leucocytosis might be explained in the same way; but after all allowance is made for such possible error there would still be left no inconsiderable leucocytosis, which is further proved real by the changes in relation between the various forms which have been recorded in Chart III.

It must further be admitted that chloroform anæsthesia (which was employed in all of these cases, sometimes alone, and again only at the start and followed by ether) may play some part in the leucocytosis following operation; for I have had the opportunity of observing that chloroform anæsthesia alone is capable of producing a leucocytosis in the peripheral blood, which, however, is scarcely more persistent than that produced by the digestion of a hearty meal, and consequently, of course, need not be seriously considered in this connection.

CHART IV. (SERIES II.)—TABLE OF ERYTHROCYTES, HÆMOGLOBIN AND NUCLEATED RED CELLS BEFORE AND AFTER OPERATION.

Case.	Time.	Erythrocytes.	Hæmoglobin (v. Fleischl).	Color index.	Number of nucleated red cells per 300 leucocytes.
I.	12 hours prior to operation	3,800,000	50 %	0.66	One.
I.	30 hours after operation	4,800,000	65 %	0.68	Four.
I.	130 " " "	4,600,000	60 %	0.65	None.
II.	18 hours prior to operation	4,800,000	85 %	1.00	One.
II.	24 hours after operation	4,600,000	92 %	1.00	None.
II.[1]	168 " " "	…………	………	……	"
III.	18 hours prior to operation	3,800,000	82 %	1.08	"
III.	24 hours after operation	4,700,000	85 %	0.90	Two.
III.	120 " " "	3,900.000	85 %	1.09	None.
IV.	12 hours prior to operation	3,400,000	80 %	1.18	One.
IV.	30 hours after operation	3,900,000	90 %	1.15	None.
IV.	126 " " "	3,100,000	70 %	1.13	"
V.	3 days prior to operation	3,600,000	70 %	1.00	"
V.	24 hours after operation	3,800,000	75 %	1.00	"
V.[2]	11 days " "	2,400,000	55 %	1.14	"
VI.	12 hours prior to operation	3,400,000	80 %	1.18	"
VI.	30 hours after operation	3,500,000	80 %	1.14	"
VI.	150 " " "	3,000,000	60 %	1.33	"
VII.	2 days prior to operation	3,100,000	50 %	0.80	"
VII.	30 hours after operation	3,900,000	65 %	0.83	"

The conclusions which I think may be safely drawn from the foregoing are:

1. An increase of from 5000 to 10,000 leucocytes per cubic millimetre following operation in from six to thirty-six or even forty-eight

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[1] The record of this examination for estimation of red cells and hæmoglobin has been lost.

[2] This is the case before spoken of, in which a persistent diarrhœa followed operation, causing secondary anæmia.

hours is a normal post-operative condition, provided it be not sustained.

2. Probably the maximum leucocytosis in the majority of cases occurs within the first twelve hours after operation, and is very transient.

3. The leucocytosis in the normal reparative process bears but slight relation to the pulse and temperature.

4. A post-operative leucocytosis of 10,000 or more *above the individual normal* sustained for more than a few hours may be looked upon with suspicion.

5. The apparent increase in number of erythrocytes following operation is not caused by an actual increase of red cells in the circulating blood.

To Drs. Eugene Boise and Richard R. Smith, of Butterworth Hospital, and Drs. Schuyler Graves and O. E. Herrick, of the Union Benevolent Association Hospital, I am indebted for the opportunity of making these observations, every courtesy possible being extended me by all of these gentlemen during their respective services.

ENTRANCE OF AIR INTO THE VEINS, AND ITS TREATMENT.

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Although the dangers accompanying sudden entrance of air into the venous circulation were recognized early in the eighteenth century by such observers as Redi, Valsalva, and Morgagni, it remained for Beauchesne, in 1818, to first report a death, verified by autopsy, due to entrance of air into the jugular vein during an operation for the removal of a tumor from the neck.

The discussion following Beauchesne's report has been carried on during the past century by such clinicians and experimentalists as Barlow, Mirault, Delaporte, Ammussat, Cormack, Wattman, and others—during the early part of the nineteenth century—and later by Senn, Hare, Treves, Porter, Hektoen, Draper, and Davidson.

The conclusions which have been reached are various. On the one hand, we have heard warnings against its dangers; others have endeavored to dispel the dread of this accident existing among surgeons. Some have taught that the merest bubble of air entering the veins may cause alarming symptoms, possibly death; while others have